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PCT Applicant's Guide - Volume II - National Chapter - US

Annex US.II, page 1

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| U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE | | ATTORNEY'S DOCKET NUMBER HAC-026 |
| TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371 | | U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/744205 |
| INTERNATIONAL APPLICATION NO. PCT/AU99/00591 | INTERNATIONAL FILING DATE 21 July 1999 | PRIORITY DATE CLAIMED 21 July 1998 |
| TITLE OF INVENTION ION SOURCE | | |
| APPLICANT(S) FOR DO/EO/US SAINTY, Wayne G. | | |
| Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information: | | |
| <ol style="list-style-type: none">1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.3. <input checked="" type="checkbox"/> This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).4. <input checked="" type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))<ol style="list-style-type: none">a. <input checked="" type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau).b. <input type="checkbox"/> has been transmitted by the International Bureau.c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).6. <input type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)).7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))<ol style="list-style-type: none">a. <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau).b. <input type="checkbox"/> have been transmitted by the International Bureau.c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.d. <input type="checkbox"/> have not been made and will not be made.8. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).10. <input type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)). | | |
| Items 11. to 16. below concern document(s) or information included: | | |
| <ol style="list-style-type: none">11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.12. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.13. <input type="checkbox"/> A FIRST preliminary amendment. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment.14. <input type="checkbox"/> A substitute specification.15. <input type="checkbox"/> A change of power of attorney and/or address letter.16. <input type="checkbox"/> Other items or information: | | |

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| U.S. APPLICATION NO. (37 CFR 1.51) | | INTERNATIONAL APPLICATION NO. | | ATTORNEY'S DOCKET NUMBER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|------------------|-------------------------------|-----------|---|--------------|--------------|------|--|--------------|-----------|---|-----------|----|--------------------|---------|---|--------|----|---|--|--|--|---------|--|--|--|---------|--|----|--|--------|--|--------|--|----|--|-------|--|--------|--|------------------|--|----------|--|------------|
| 09/744205 | | PCT/AU99/00591 | | HAC-026 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>17. <input checked="" type="checkbox"/> The following fees are submitted:</p> <p>BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :</p> <p>Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or IPO \$1000</p> <p>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or IPO \$860</p> <p>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$710</p> <p>International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690</p> <p>International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$100</p> <p style="text-align: right;">ENTER APPROPRIATE BASIC FEE AMOUNT =</p> | | | | <p>CALCULATIONS PTO USE ONLY</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).</p> <table border="1" style="width: 100%; border-collapse: collapse; font-size: small;"> <thead> <tr> <th style="width: 20%;">CLAIMS</th> <th style="width: 20%;">NUMBER FILED</th> <th style="width: 20%;">NUMBER EXTRA</th> <th style="width: 20%;">RATE</th> <th style="width: 20%;"></th> </tr> </thead> <tbody> <tr> <td>Total claims</td> <td>18 - 20 =</td> <td>0</td> <td>X \$18.00</td> <td>\$</td> </tr> <tr> <td>Independent claims</td> <td>2 - 3 =</td> <td>0</td> <td>X \$80</td> <td>\$</td> </tr> <tr> <td colspan="4">MULTIPLE DEPENDENT CLAIM(S) (if applicable)</td> <td>+ \$270</td> </tr> </tbody> </table> <p style="text-align: right;">TOTAL OF ABOVE CALCULATIONS =</p> <p>Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).</p> <p style="text-align: right;">SUBTOTAL =</p> <p>Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).</p> <p style="text-align: right;">TOTAL NATIONAL FEE =</p> <p>Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +</p> <p style="text-align: right;">TOTAL FEES ENCLOSED =</p> | | | | CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | | Total claims | 18 - 20 = | 0 | X \$18.00 | \$ | Independent claims | 2 - 3 = | 0 | X \$80 | \$ | MULTIPLE DEPENDENT CLAIM(S) (if applicable) | | | | + \$270 | <table border="1" style="width: 100%; border-collapse: collapse; font-size: small;"> <tbody> <tr> <td style="width: 50%;"></td> <td style="width: 50%; text-align: right;">\$ 1000</td> </tr> <tr> <td></td> <td style="text-align: right;">\$</td> </tr> <tr> <td></td> <td style="text-align: right;">\$ 500</td> </tr> <tr> <td></td> <td style="text-align: right;">\$ 500</td> </tr> <tr> <td></td> <td style="text-align: right;">\$</td> </tr> <tr> <td></td> <td style="text-align: right;">\$ 40</td> </tr> <tr> <td></td> <td style="text-align: right;">\$ 540</td> </tr> <tr> <td></td> <td style="text-align: right;">Amount to be: \$</td> </tr> <tr> <td></td> <td style="text-align: right;">refunded</td> </tr> <tr> <td></td> <td style="text-align: right;">charged \$</td> </tr> </tbody> </table> | | | \$ 1000 | | \$ | | \$ 500 | | \$ 500 | | \$ | | \$ 40 | | \$ 540 | | Amount to be: \$ | | refunded | | charged \$ |
| CLAIMS | NUMBER FILED | NUMBER EXTRA | RATE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total claims | 18 - 20 = | 0 | X \$18.00 | \$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Independent claims | 2 - 3 = | 0 | X \$80 | \$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | charged \$ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>a. <input checked="" type="checkbox"/> A check in the amount of \$ <u>540.00</u> to cover the above fees is enclosed.</p> <p>b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.</p> <p>c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. _____. A duplicate copy of this sheet is enclosed.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>07-1732</p> <p>NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>SEND ALL CORRESPONDENCE TO:</p> <div style="display: flex; justify-content: space-between; align-items: flex-end;"> <div style="width: 60%;"> <p>David P. Gordon 65 Woods End Road Stamford, CT 06905</p> </div> <div style="width: 35%; text-align: right;"> <p><i>David P. Gordon</i> SIGNATURE: David P. Gordon NAME 29,996 REGISTRATION NUMBER</p> </div> </div> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Applicant or Patentee: _____ Attorney's
Serial or Patent No.: _____ Docket No.: _____
Filed or Issued: _____
For: _____

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY
STATUS (37 CFR 1.9 (f) and 1.27 (c)) — SMALL BUSINESS CONCERN

I hereby declare that I am

- ☐ the owner of the small business concern identified below;
☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN Saintech Pty Limited (ACN 086 520 809)
ADDRESS OF CONCERN 40 Bingara Street, Beecroft, NSW, 2119, Australia

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 37 CFR 1.21.3-18, and reproduced in 37 CFR 1.9 (d), for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention, entitled ION SOURCE

by inventor(s)
described in

- ☐ the specification filed herewith
☐ application serial no. _____, filed _____
☐ patent no. _____, issued _____

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below* and no rights to the invention are held by any person, other than the inventor, who could not qualify as an independent* under 37 CFR 1.9 (c) or by any concern which would not qualify as a small business concern under 37 CFR 1.9 (d) or a nonprofit organization under 37 CFR 1.9 (e)
*inventor

*NOTE. Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities (37 CFR 1.27)

NAME _____
ADDRESS _____
☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

NAME _____
ADDRESS _____
☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28 (b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed

NAME OF PERSON SIGNING Wayne G Sainty
TITLE OF PERSON OTHER THAN OWNER Managing Director
ADDRESS OF PERSON SIGNING 40 Bingara Street, Beecroft, NSW, 2119, Australia

SIGNATURE X W G Sainty DATE 8/1/2001

09/744205

ION SOURCE 9007 Rec'd PCT/PTO 18 JAN 2001

BACKGROUND OF THE INVENTION

This invention relates to ion sources for producing an ion beam. The invention was
5 developed through use with end-Hall effect ion sources and is, at times, described
with particular reference thereto. It will be apparent to the skilled reader however,
that the scope of the invention will encompass other types of ion sources.

10 Ion sources had their origins in space propulsion but more recently have found use in
more industrial processes such as Ion Assisted Deposition (IAD) of thin film coatings.
In an IAD process, an ion beam from an ion source is focussed onto a target substrate
to cause densification of the coating material as it is deposited. The process occurs
within an evacuated chamber of pressure of the order 10^{-2} Pa.

15 In a typical ion source, electrons are drawn from a cathode filament toward an anode
through an ionisable gas. Collisions between the gas molecules and energetic
electrons create a source of positive ions by inducing a plasma. In one type of ion
source known as a gridless ion source, a magnetic field is applied across the plasma to
shape the ions accelerated from the ion source into an ion beam. In a specific type of
20 gridless ion source, known as an end-Hall effect ion source, the axis of the magnetic
field is aligned with the electric potential between the cathode and the anode. The
interaction of the magnetic and electric fields causes the charged particles to
approximately follow the magnetic field lines. The anode in these devices is typically
annular having an outwardly inclined inner diameter with the bulk of the plasma
25 forming within the confines of the anode walls.

An example of the an end-Hall effect ion source in common use, in particular in IAD
techniques, is described in US Patent No. 4 862 032 to Kaufman et al. In this device,
herein referred to as the Kaufman device, the ionisable gas is distributed uniformly
30 across the plasma region. Magnetic field shaping disperses the electrons across the
gas to ensure a large plasma capable of producing a high ion beam current. The result

is that a relatively high gas flow (typically up to 50 sccm) is required to maintain a sufficient pressure in the plasma region to achieve ionisation of the gas. The resultant high background pressure within the interelectrode space creates electrical instability leading to the generation of cathode spots within the ion source and extending to the
5 extremities of the vacuum environment. In addition, large vacuum pumps are required to maintain a sufficiently low pressure within the rest of the evacuated chamber to be compatible with the operation of other equipment used in IAD and other processes. In operation the pressure can only be increased to the point where the ion beam current is approximately 1 Amp before further instabilities are introduced.

10

A further problem with present ion sources is that their performance can decrease over the life of the ion source. Symptoms include difficulty in establishing the plasma and a reduced stability of the plasma. Investigations by the present inventor have found that the reduced performance capabilities are created, at least in part, by a decrease in
15 the electron flux entering the ionisation region due to a reduction in the effective surface potential of the anode. Further investigation into the cause of the reduced potential by the present inventor found that a dielectric oxide layer built up on the surface of the anode exposed to the plasma. It was previously believed that the observed build up of electrically insulating coatings on the anode were produced by
20 scattering and sputtering from the thin film deposition processes for which these ion sources were commonly used. The inventor has found that the dielectric layer actually arises from a small percentage of negative ions produced in an oxygen plasma interacting with the surface of the anode and that this has the effect of shielding the anode from the cathode, dispersing the electron flow from the cathode and thus
25 reducing the electron flux into the ionisation region. The reduced electron flux into the ionisation region firstly creates instability in the performance of the ion source and, secondly, causes an imbalance in the charge neutrality of the resultant ion beam.

SUMMARY OF THE INVENTION

30

In a first form, the present invention resides in an ion source including a cathode, an anode, an ionisation region between said cathode and said anode, means for

- introducing an ionisable gas into said ionisation region, means for creating a potential difference between said cathode and said anode to produce a flow of electrons from said cathode toward said anode, said electron flow passing substantially through said ionisation region and causing ionisation of said gas, means for concentrating said
- 5 electron flow to create a region within said ionisation region where the electron flux is a maximum, and means acting to expel ions created in said ionisation region from said ion source, wherein said ionisable gas is introduced into said ionisation region at a localised area in proximity to said region of maximum electron flux.
- 10 Preferably the concentration of electrons and the expulsion of ions from the ion source is achieved using a magnetic field.

- More preferably, the axis of the magnetic field lies substantially parallel to the direction of the electric potential between the anode and the cathode. With the
- 15 magnetic and electric fields aligned in this way, the maximum electron flux occurs at the maximum magnetic field intensity.

- The invention also provides an ion source including a cathode, an anode, an ionisation region between said cathode and said anode, means for introducing an ionisable gas
- 20 into said ionisation region, means for creating a potential difference between said cathode and said anode to produce a flow of electrons from said cathode toward said anode, said electron flow passing substantially through said ionisation region and causing ionisation of said gas, and means acting to expel ions created in said ionisation region from said ion source, wherein said anode has at least one surface
- 25 exposed to said ionisation region, at least a portion of said at least one exposed surface being of an electrically conducting non-oxidising material.

- Preferably the anode is annular having an axis lying in the same direction as the electric field between the anode and the cathode. The exposed surfaces of the anode
- 30 are preferably a coating of Titanium Nitride (TiN).

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages of the invention will become apparent to the skilled reader from the following description of preferred embodiments made with reference to the accompanying Figures in which:

5

Figure 1 is a partial cross-sectional elevation of the ion source according to the invention.

Figure 2 is a plan view of the ion source in figure 1.

10

Figure 3 is a cross-sectional view of a preferred form of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

- 15 Figures 1 and 2 show an ion source generally at 10 having a cathode wire 11 and an anode 12. The anode 12 is an annulus having an inner surface 35 sloping outwards in the direction of the cathode. Between the cathode 11 and the anode 12 is an ionisation region 13. The cathode wire 11 is suspended above the anode by two mounting pins 20 that are held by, and in electric isolation from a shield plate 30. The shield plate 30 substantially surrounds the anode, cathode and ionisation region by extending from a point lower than the anode 12 to a point above the cathode 11 and is preferably maintained at earth potential to shield the anode and the cathode from external fields. A magnet 14 is disposed outside the ionisation region 13 but adjacent the anode 12. The magnet 14 creates a magnetic field, the longitudinal axis of which is aligned with the axis of the anode 12. The magnet may be a permanent magnet or an
25 electromagnet. Preferably the magnet is a high flux rare earth magnet such as a NdFeB magnet. As an alternative, magnet 14 may be a ring magnet disposed around the anode 12 and ionisation region 13.
- 30 The alignment of the magnetic field with the electric field causes electrons emitted by the cathode to approximately follow the magnetic field lines as they move towards the anode. This has the effect of concentrating the flow of electrons toward the axis of the

magnetic field. Therefore the region where the magnetic field intensity is a maximum, will also be a region of maximum electron flux.

The ionisable gas, for example oxygen, nitrogen or argon, is supplied to the ionisation region through a gas flow path from gas feed line 22. The gas flow path terminates at an outlet member 15. The outlet member 15 has the form of a gas shower head, with a plurality of apertures 17, that introduce the gas into the ionisation region 13 in a substantially random direction. The gas shower head 15 is disposed on the axis of the anode and adjacent the ionisation region 13 such that gas emanating from the apertures 17 enters the ionisation region at a point of high electron flux. Because a large proportion of ionisation occurs close to the outlet, the gas shower head is of a material such as stainless steel, that withstands the very high energy from the incoming electron flux.

The anode 12 preferably has disposed within it a channel 53 in communication with a fluid conduit 55 that provides water to cool the anode. The channel 53 preferably extends into the body of the outlet member 15.

The anode 12, outlet member 15 and shield 30 are mounted on a non conductive mounting base 50 through which extends the gas flow path and fluid conduit 55. A plurality of mounting screws 57 fix the anode 12 to the base 50. The magnet 14 is housed within the base such that the external pole is exposed. The mounting base 50 has a conduit 58 that forms part of the gas flow path and connects the gas feed line 22 to the outlet member 15 such that no electrical connection can be made between the outlet member 15 and the gas feed line 22. The mounting base 50 has a similar conduit for connecting the water feed line 55 to the channel 53. The gas and water feed lines preferably screw into the mounting base 50. A suitable material for the mounting base 50 is glass filled polytetrafluoroethylene. This arrangement reduces electrical hazards, simplifies mounting and installation and reduces risk of secondary plasmas forming within the gas feed line.

The size of the outlet is preferably half or less than the smallest inner diameter of the anode in order that a localised high pressure zone is created around the outlet, that decreases rapidly with distance.

- 5 In operation the anode is charged in the range 0-500 V, preferably 250 V relative to the cathode which is at or near earth potential. A DC current of approximately 12A is passed through the cathode to stimulate electron emission. An AC current may be used but the combination of an alternating current and the magnetic field has been found to cause vibrations in the cathode which reduces the cathode lifetime. Electrons
10 generated at the cathode are influenced by the anode potential and are accelerated toward it. The magnetic field imparts a spiral motion on the electrons further increasing their potential to ionise gas molecules and focussing the electrons toward the longitudinal axis. Collisions between the energetic electrons with gas molecules emitted from the outlet member 15 cause ionisation. If sufficient ionising collisions occur then a plasma is formed. Positive ions created in the plasma experience the opposite effect to the electrons. The ions initially have a random velocity but are influenced by the potential gradient which accelerates them toward and past the cathode 11. The magnetic field in this case acts to control the direction in which the ions are expelled from the ion source by focusing them into an ion beam centred on
20 the longitudinal axis of the magnetic field. The dynamics of the interactions between the ions and the electric and magnetic fields for this configuration are known per se, for example from the above mentioned Kaufman patent. The current of the ion beam is effected by the size of the plasma which can be controlled by the gas flow rate.
- 25 The plasma can be maintained for a wider range of gas flow rates than for prior art ion sources because there is always at least a localised region of high pressure. The range of gas flows gives a corresponding range in the ion beam currents. A further advantage is that lower gas flow rates are required to achieve the equivalent or higher beam currents than for prior art devices. For example a gas flow rate of 4-5 sccm can
30 achieve a beam current of 2 A in the present invention compared with 10-50 sccm required to produce 1 A of beam current in devices of the above mentioned Kaufman

type. These lower gas flow rates assist in allowing a low background pressure to be maintained.

- 5 A further benefit of reduced flow rate is that the operational requirements of the vacuum pumping system used to evacuate the chamber in which the ion source is disposed can be reduced, while still maintaining lower background pressures than achieved in many prior art devices. This increases stability by reducing the chances of arcing and sputtering in the peripheral regions of the ion source.
- 10 Operating background pressures of the order 10^{-3} Pa have been achieved with the present invention. At these pressures the mean free path of the ions is of the order of metres. This is important in many ion source applications because it is typically many times longer than the dimensions of the vacuum environment. For IAD processes, mean free paths of this order are longer than the typical distance between the ion
- 15 source and the target substrates. The efficiency of the deposition process is therefore enhanced by these low background pressures because more primary ions impact the target substrates instead of undergoing secondary collisions with gas molecules. A further benefit of the reduced pressure is that contamination of the thin film coating, is considerably reduced.
- 20 The anode 12 is preferably made of stainless steel but has a coating of a non-oxidising electrically conductive material, for example TiN, on the inner surface 35 and any other surface that in use may be exposed to bombardment by electrons and/or negative ions from the plasma. The inner surface coating is unreactive with any negative ions
- 25 produced in the plasma and therefore resists the build up of a dielectric layer on the anode surface. This provides a long term benefit in the performance of the ion source because a dielectric coating would shield the anode potential from the cathode. This would reduce the concentration of electrons flowing into the ionisation region, thus reducing the size of the plasma and in turn the ion beam current. In addition, the
- 30 concentration of electrons in peripheral regions of the ion source would increase, thereby increasing the frequency of arcing and sputtering in these regions. By coating

the anode in a non-oxidising material, these problems can be eliminated as can the cleaning procedures previously required to maintain the anode in working order.

Because the ion source 10 operates at a low background pressure the anode and
5 cathode can be in closer proximity than in previous devices. Figure 3 shows a preferred form of the invention where the inner edge 31 of the plasma shield 30 extends towards the anode 12. Preferably the inner edge 31 of the shield 30 is disposed outside a projection of the inner surface 35 of the anode 12. The extended edge 31 has a flange 32 that surrounds an upper portion of the anode 12. The purpose
10 of the flange 32 is to prevent gas entering the region 40 enclosed by the anode 12 and shield 30 where the gas could be ionised and cause electrical instability. A vent hole 41 is provided from the region 40 to outside the ion source to allow sufficient pumping of this region, thus ensuring a low pressure. To further prevent any instabilities an o-ring seal (not shown), preferably of an elastomer material, can be
15 disposed between the flange 32 and an upper portion of the anode 12.

While particular embodiments of this invention have been described, it will be evident to those skilled in the art that the present invention may be embodied in other specific forms without departing from the essential characteristics thereof. The present
20 embodiments and examples are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

CLAIMS

1. An ion source including a cathode, an anode, an ionisation region between said cathode and said anode, means for introducing an ionisable gas into said ionisation
5 region, means for creating a potential difference between said cathode and said anode to produce a flow of electrons from said cathode toward said anode, said electron flow passing substantially through said ionisation region and causing ionisation of said gas, means for concentrating said electron flow to create a region within said ionisation
10 region where the electron flux is a maximum, and means acting to expel ions created in said ionisation region from said ion source, wherein said ionisable gas is introduced into said ionisation region at a localised area in proximity to said region of maximum electron flux.
2. An ion source according to claim 1 wherein said ion expelling means includes
15 means for creating a magnetic field, said magnetic field acting to influence the direction in which said ions are expelled from said ion source.
3. An ion source according to claim 1 further including means for creating a magnetic field, said magnetic field having a longitudinal axis substantially parallel
20 with an axis of an electric field created by said potential difference between said cathode and said anode, and wherein said maximum electron flux substantially coincides with a maximum of the magnetic field intensity such that said magnetic field forms at least part of said means for concentrating said electron flow.
- 25 4. An ion source according to claim 3 wherein said anode is annular having an axis in substantial alignment with said magnetic field axis.
5. An ion source according to claim 4 wherein said gas introducing means
30 includes a gas flow path terminating at an outlet member, said outlet member being disposed on or near said anode axis and substantially adjacent said ionisation region.

6. An ion source according to claim 5 wherein said outlet member is electrically conductive and is maintained at substantially the same potential as the anode.

5 7. An ion source according to claim 6 wherein said outlet member is integral with said anode.

8. An ion source according to claim 5 wherein said anode includes an internal fluid channel in communication with a fluid conduit supplying fluid to cool said anode.

10

9. An ion source according to claim 8 wherein said fluid channel extends into said outlet member.

10. An ion source according to claim 5 wherein said anode is mounted on a base of electrically insulating material, said base including a channel forming a part of said gas flow path.

11. An ion source according to claim 4 wherein said anode, said cathode and said ionisation region are substantially surrounded by an electrically conductive shield maintained substantially at earth potential.

12. An ion source according to claim 4 wherein said anode includes at least one surface exposed to said ionisation region, at least a portion of said at least one surface being of an electrically conductive non-oxidising material.

25

13. An ion source according to claim 12 wherein said electrically conductive non-oxidising material is Titanium Nitride.

14. An ion source including a cathode, an anode, an ionisation region between said cathode and said anode, means for introducing an ionisable gas into said ionisation region, means for creating a potential difference between said cathode and said anode to produce a flow of electrons from said cathode toward said anode, said electron flow

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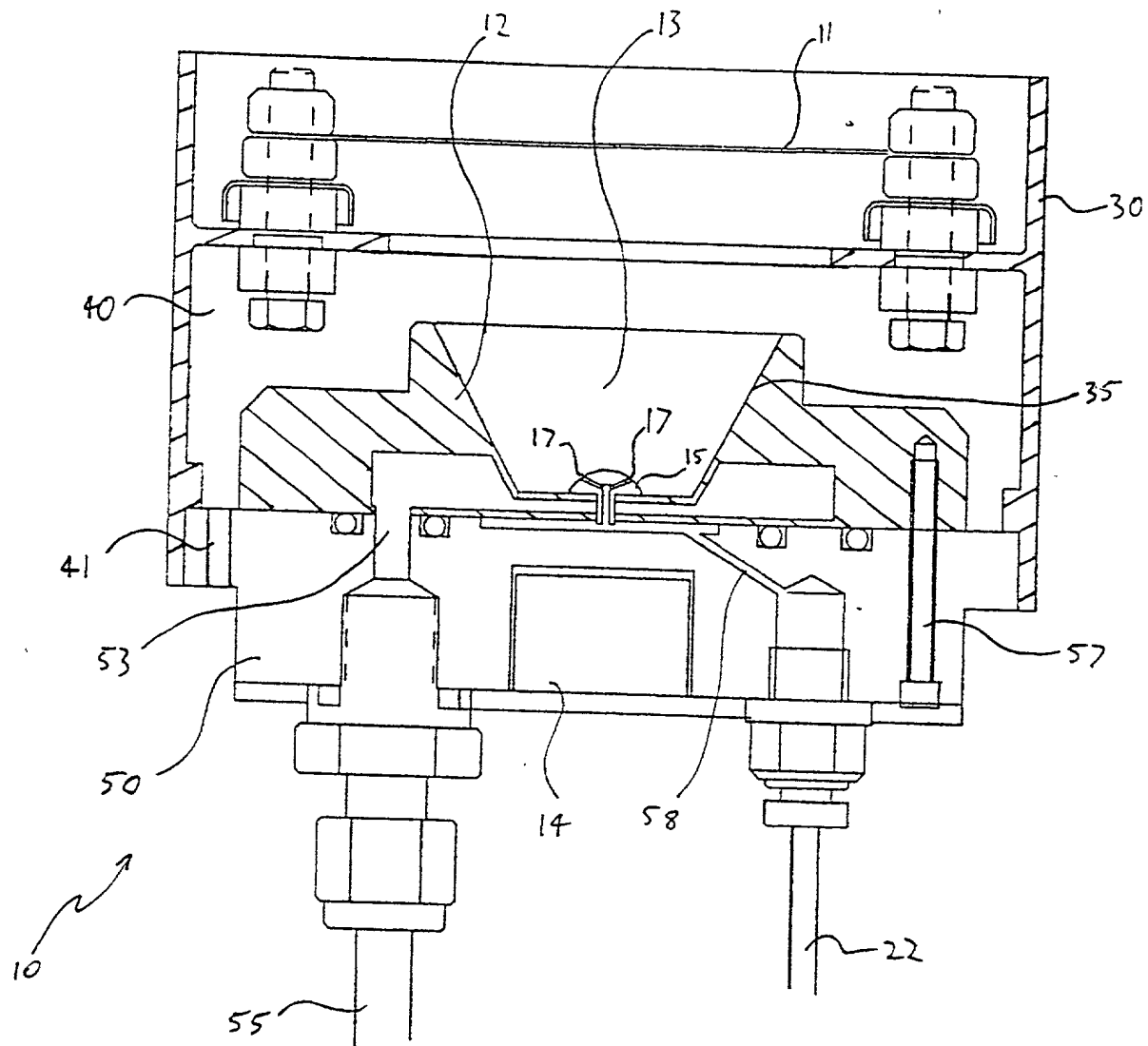
passing substantially through said ionisation region and causing ionisation of said gas, and means acting to expel ions created in said ionisation region from said ion source, wherein said anode has at least one surface exposed to said ionisation region. at least a portion of said at least one exposed surface being of an electrically conductive non-oxidising material.

15. An ion source according to claim 14 wherein said at least one exposed surface is a layer of Titanium Nitride coated onto said anode.

10 16. An ion source according to claim 14 wherein said anode is annular and includes an inner surface sloping outwards in the direction of said cathode, said inner surface being exposed to said ionisation region and at least a portion of said inner surface being of electrically conductive non-oxidising material.

15 17. An ion source according to claim 16 wherein substantially the entire inner surface of said anode is of an electrically conductive non-oxidising material.

18. An ion source according to claim 16 wherein said gas introducing means includes an outlet member disposed substantially at the centre of said anode, said
20 outlet member having a surface of electrically conductive non-oxidising material.

Figure 1

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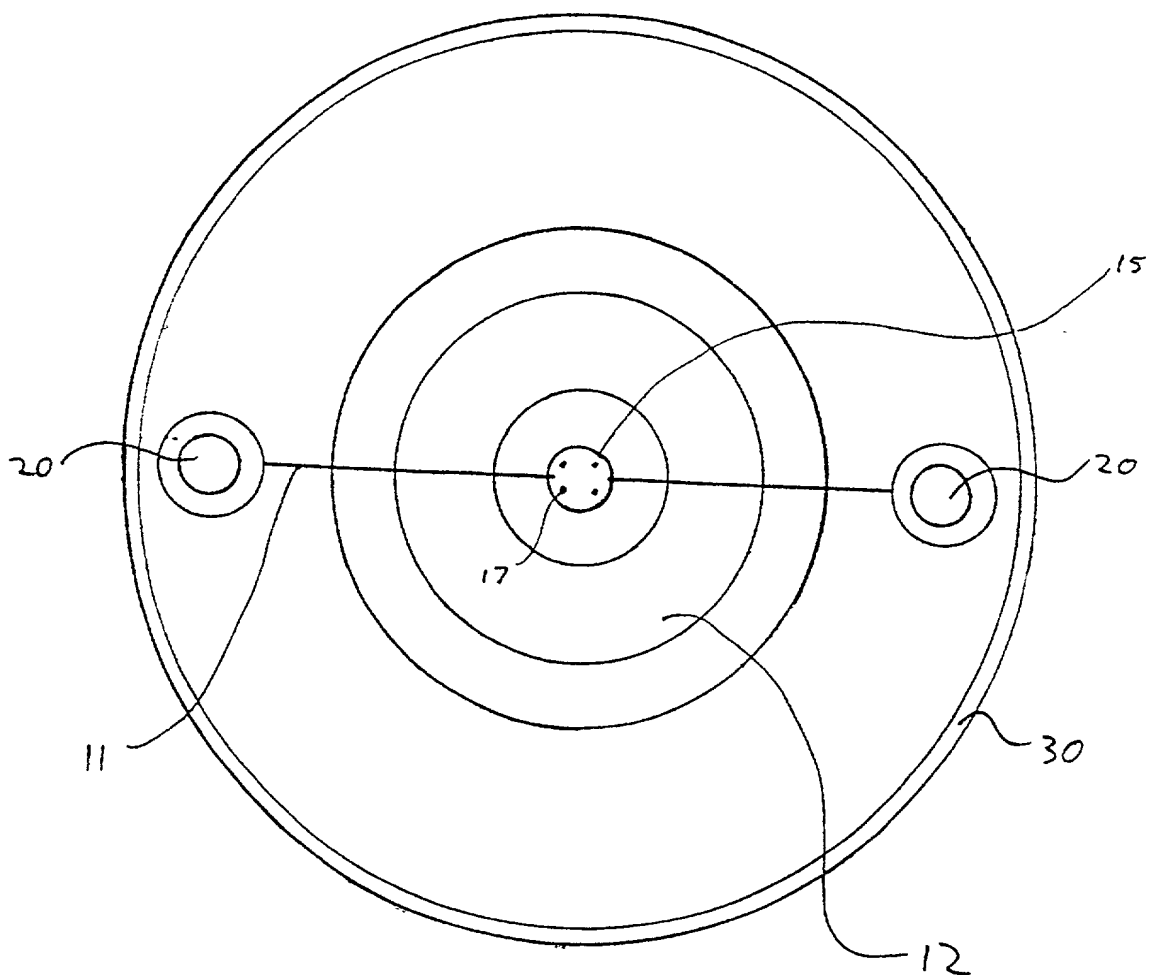
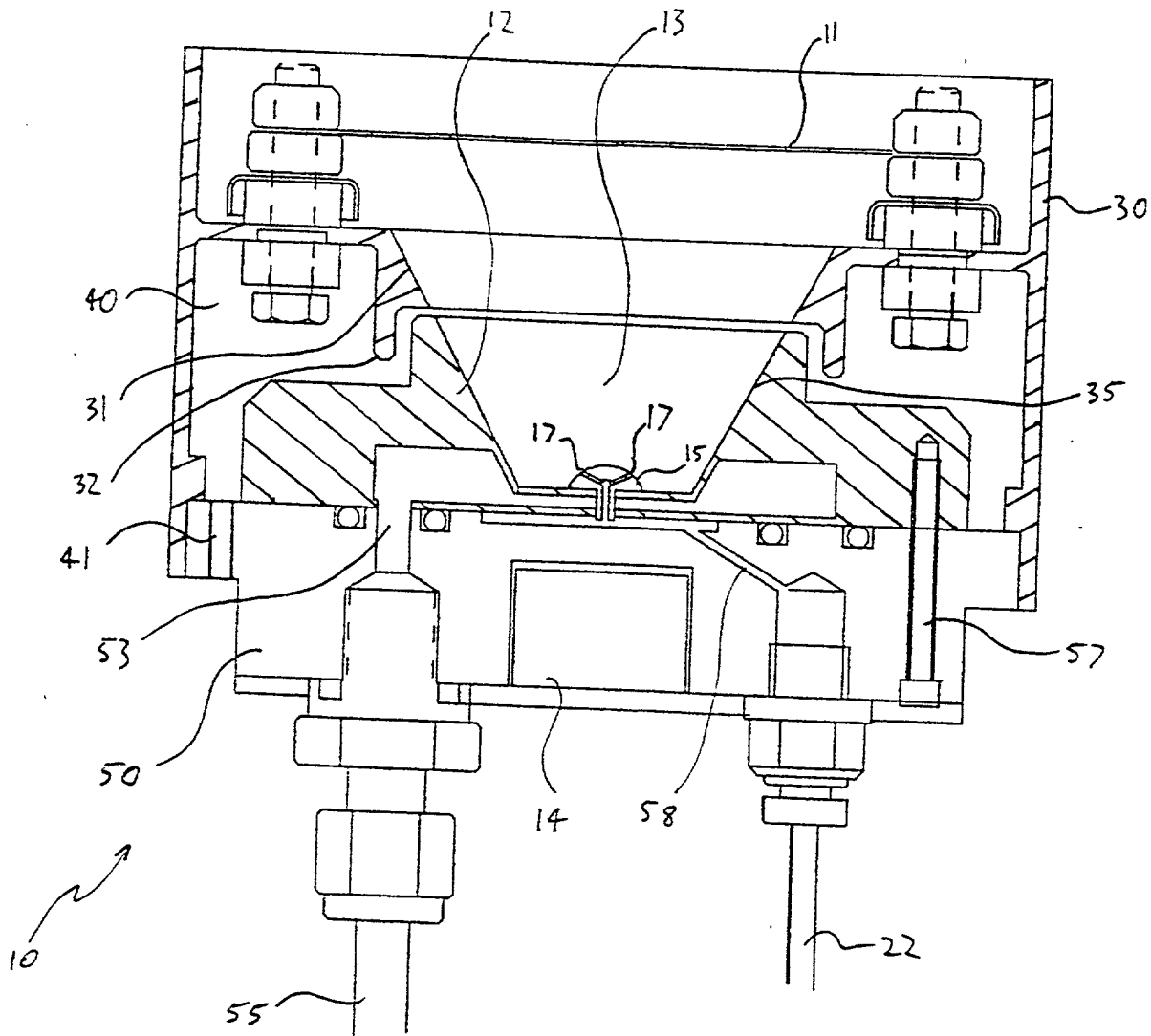


Figure 2

FIG. 2

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Figure 3

DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name, and

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

ION SOURCE

_____, the specification of which

☐ is attached hereto.

☐ was filed on _____

as Application Serial Number _____

and was amended on (if applicable) _____

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by an amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

Priority Claimed

| | | | | |
|----------|-----------|--------------|---|-----------------------------|
| PP4792 | Australia | 21/7/1998 | <input checked="" type="checkbox"/> YES | <input type="checkbox"/> NO |
| (Number) | (Country) | D/M/YR FILED | | |

| | | | | |
|----------|-----------|--------------|------------------------------|-----------------------------|
| _____ | _____ | / / | <input type="checkbox"/> YES | <input type="checkbox"/> NO |
| (Number) | (Country) | D/M/YR FILED | | |

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which occurred between the filing date

of the prior application and the national or PCT international filing date of this application:

(Application Ser. No) (Filing Date) (Status-Patented, pending, abandoned)

(Application Ser. No) (Filing Date) (Status-Patented, pending, abandoned)

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

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U.S.A.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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